The Royal College of Surgeons
in London.—
From the Author.

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1839, *p.* 265.)

On the Classifications of the Amphibia. By JOHN HOGG, Esq., M.A., F.L.S., C.P.S., &c.[1]

IN my short paper "On the Snake-like *Proteus*," contained in the first volume of the new series of the 'Magazine of Natural History,' I assumed the *permanency* of the *gills*,—from a long acquaintance with that remarkable fact,—as the principle upon which the *Proteus* ought to be characterised, not only in conformity with its natural organization, but likewise in respect to its position in the animal kingdom, as so nearly approximating to some kinds of fishes.

Whilst examining Mr. Jenyns's excellent 'Manual of British Vertebrate Animals,' I found, at p. 299, that he arranged our native species in the class *Amphibia*, and in an order termed "*Caducibranchia*," from the *gills* being "deciduous;" it very naturally occurred to me to form for the *Proteus* another order, which I named *Manentibranchia*, signifying the *gills* remaining *permanent;* and this I decided on, without investigating under what orders or groups zoologists (with the exception of Linnæus and Cuvier) had distributed the genera of amphibious animals.

Having lately had an opportunity of paying some attention to this class of animals, I shall venture, after giving an outline of the different arrangements that have been adopted by several of the modern naturalists, to add one—partly indeed derived from that of Latreille—which I hope, notwithstanding our imperfect knowledge of the rarer American kinds, may not altogether be disregarded by those zoologists who are more conversant in the highly interesting subject of Amphibiology.

To begin with Linnæus. He arranged such of these animals (except the genus *Cæcilia*) as were then known, in his last (the 12th) edition of the 'Systema Naturæ,' 1766, under the first order, Reptiles, of the third class,—*Amphibia;* and which were all comprised in only *two* genera,—*Rana* and *Lacerta.*

Laurenti, about the same time (1768), publishing his 'Synopsis Reptilium,'—a work which then contained more accurate and further information of these animals, than any other that had appeared, and is still accounted one of authority and reference,—divided his seven genera into two orders, viz., those reptiles which *leap* in their progressive motion, and those which *walk;* as follow.—

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[1] Communicated by the Author. Read at the Linnean Society, Feb. 6, 1838.

CLASSIS.—*REPTILIUM.*

Ordo I.—SALIENTIA. Genera.—*Pipa. Bufo. Rana. Hyla.*
Ordo II.—GRADIENTIA. Genera.—*Proteus. Triton. Salamandra.*

The Count de La Cépède, in the 'Hist. Nat. des Quad. Ovip.' tome i., which was given to science in 1788, naming them *Oviparous Quadrupeds,* classed his four genera just as simply, by taking for his characters the presence and absence of a *tail;* thus.—

CLASSIS I.—Quadrupedes ovipari *caudati.*
Gen. II. *Lacertus.* Div. 8. *Salamandra.*

CLASSIS II.—Quadrupedes ovipari *ecaudati.*
Genera.—*Rana. Hyla. Bufo.*

Duméril, (Zoologie Analytique, 1806), as Daudin had before done in his beautiful work,—'Hist. Nat. des Reptiles,' 1802,—followed Brongniart, (see his Essai dans le 'Bulletin de la Société Philomatique,' No. 36), who in 1799 first divided the class *Reptilia* into four orders, and in the last of which he placed these animals. Duméril distinguished them, after La Cépède, by the want and presence of a *tail,* and merely assigned them new Greek, instead of the old Latin, titles. His genera are the same as Laurenti's, with the addition of *Siren;* as are here seen.

CLASSE III.—REPTILES.

Ordre 4. BATRACIENS.

1re Famille. Anoures. *Sans queue.*
Genres.—Pipa. Crapaud. Grenouille. Rainette.

2de Famille. Urodèles. *Avec une queue.*
Genres.—Triton. Salamandre. Protée. Sirène.

The same system is adopted again, but with a new family, by Oppel in his 'Reptilien,' 1811; as follows.

CLASSIS III.—*REPTILIA.*

Ordo III. NUDA, (Klein). Ordo IV. BATRACHII, (Brongniart).

1. Familia.—*Apoda.* Genus.—*Cæcilia.*

2. Familia.—*Caudata*, (Duméril).
Genera.—*Triton*. *Salamandra*. *Proteus*. *Siren*.
3. Familia—.*Ecaudata*, (Duméril).
Genera.—*Hyla*. *Rana*. *Pipa*. *Bufo*.

Merrem published his 'Tentamen Systematis Amphibiorum' in the year 1820, wherein he gave a more extended arrangement; retaining Laurenti's two orders, taken from the *modes* of progression of the *feet*, he added Oppel's order,—"*Apoda*," without feet,—and two new tribes; in which latter he designated those animals that undergo a *transformation*, and those that do *not*. But it is worthy of remark, that he restricts the first tribe, *Mutabilia*, to *only Salamandra* and *Molge;* whereas he ought likewise to have included in *that* tribe *all* (equally undergoing metamorphoses in their young state) the genera of his second order, and to have placed his *Tribus* I.—*Mutabilia*, after "*Ordo* II.—*Salientia*," and before the "*Genera*," which would have rendered his classification more perfect. The original is this.—

AMPHIBIA.
Classis II.—*BATRACHIA*.
Ordo I.—Apoda. Genus.—*Cæcilia*.
Ordo II.—Salientia.
Genera.—*Calamita*. *Rana*. *Breviceps*. *Bombinator*. *Pipa*. *Bufo*.
Ordo III.—Gradientia.
Tribus 1. *Mutabilia ;* i. e. *Metamorphosin subeunt*.
Genera.—*Salamandra*. *Molge*.
Tribus 2. *Amphipneusta*. *Metamorphosis nulla*.
Genera.—*Proteus*. *Siren*.

Latreille, five years afterwards, introduced to the world a still better system, (vide 'Familles Naturelles du Règne Animal,' 1825, p. 104), in which he judiciously founded his two natural orders upon the *branchiæ* being *deciduous* in some species, and *perennial* in others, though in two families he has followed Duméril; thus.—

Seconde Classe.—AMPHIBIES. *Amphibia*.
Premier Ordre.—Caducibranches. *Caducibranchia*.
1re. Famille.—Anoures. *Anoura*, (Duméril).
Les Genres.—Pipa. Crapaud. Grenouille. Rainette.
2nd Famille.—Urodèles. *Urodela*, (Duméril).
Les Genres.—Salamandre. Triton. Axolotl.

Second Ordre.—PERENNIBRANCHES. *Perennibranchia.*
1re Famille.—Ichtyoïdes. *Ichthyoida.*
Les Genres.—Protée. Sirène.

It will be seen that Latreille places the *Axolotl* (*Siredon pisciformis*) amongst the caducibranchious *Amphibia*, but it had been previously discovered that its *branchiæ* are persistent; the details of which may be learnt from a paper by Sir Everard Home, published in the 'Philosophical Transactions' for the year 1824, p. 419. One of the accompanying plates accurately represents the external *gills* as still *remaining* on a female *Axolotl* when in the state of possessing fully developed *ovaria*, and just before the *ova* are shed;[1] thereby proving her to be a *perfect* animal. Consequently Latreille should have stationed the *Axolotl* next to the *Proteus* in his second order.

The Baron Cuvier, in both editions of the 'Règne Animal' (1817 and 1829), has merely followed Brongniart in considering the animals now under our notice, as forming a part of the third order, and the whole of the fourth order, of Reptiles, being his third class of *Vertebrata*.

Dr. Wagler, in his work entitled 'Natürliches System der Amphibien,' 1830, calls the class, (after Linnæus) *Amphibia*, in which he separates the different animals, under the names of *Testudines*, *Crocodili*, *Lacertæ*, *Serpentes*, *Angues*, making them his first five orders respectively; and then follow his

Ordo VI.—CÆCILIÆ.
Familia 1. *Hedræoglossæ.* Genus. *Cæcilia.*
Ordo VII.—RANÆ.
Familia 1. *Aglossæ.* Genus. *Asterodactylus*, (*Pipa*).
Familia 2. *Phaneroglossæ.*
Div. 1. *Cauda nulla.*
Genera.—*Dactylethra. Rana. Hyla. Ceratophrys. Breviceps. Bombinator. Bufo. Otilopha. Rhinella.*
Div. 2. *Cauda distincta.*
Genera.—*Salamandra. Triton.*

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[1] For a similar anatomical plate exhibiting the *ovaria* and *ova* of a female *Proteus anguinus*, together with its description, see 'Articolo sopra un Proteo femmina, con tavolo di Rusconi,' 1828. We must hope that some able American zootomist will ere long dissect a mature and oviferous female, of every one of the remaining *Diplopneumenous* species, and make the like illustrations, with accurate engravings, in order to determine, after this most satisfactory manner, the exact form and structure of each animal, in its perfect state.

Ordo VIII.—Ichthyodi.

Familia 1. *Hedræoglossi.*

Tribus 1. *Branchiis nullis.*

Genera.—*Menopoma. Amphiuma.*

Tribus 2. *Branchiis distinctis.*

Genera.—*Siredon. Proteus. Menobranchus. Siren.*

Some of the genera above given are not those of Wagler, but they are here introduced to avoid an unnecessary increase of synonymes. The families are characterised by the *tongue*; and the other characters are, the absence and presence of a *tail*, and of *gills*. The name of the last order is taken from Latreille.

In his 'Synopsis of the Species of the Class *Reptilia*,' appended to the 9th vol. of Cuvier's 'Animal Kingdom,' translated by E. Griffith, 1831, Mr. Gray has adopted Merrem's two tribes, under which he has arranged the following genera.

AMPHIBIA.

Section I. *Mutabilia.*—Undergoing a transformation. Gills deciduous, covered with a deciduous *operculum.*

Genera.—*Rana. Ceratophrys. Hyla. Bufo. Rhinella. Otilopha. Dactylethra. Bombinator. Breviceps. Pipa. Salamandrina. Salamandra. Molge.*

Section II. *Amphipneusta.*—Not undergoing transformation.

Genera.—*Proteus. Menobranchus. Siredon. Siren. Pseudobranchus. Menopoma. Amphiuma. Cæcilia.*

With regard to the next classification, Professor Bell observes,—"it appears to me that no one arrangement hitherto given sufficiently distinguishes the different forms; and I venture to propose the following modifications, as more consistent with the diversities of structure in the different groups."

Class.—*AMPHIBIA.*

Order 1. Amphipneusta. Genera.—*Proteus. Siredon. Menobranchus. Siren. Pseudobranchus.*

Order 2. Anoura. Genera.—*Rana. Hyla. Ceratophrys. Bufo. Rhinella. Otilopha. Dactylethra. Bombinator. Breviceps.*

Order 3. Urodela. Genera.—*Salamandrina. Salamandra. Molge.*

Order 4. Abranchia. Genera.—*Menopoma. Amphiuma.*

Order 5. Apoda. Genus.—*Cæcilia.*

This arrangement comprehending, 1st, the manner of *breathing*; 2ndly, the *absence* of a *tail* in the adults; 3rdly, the *presence* of a long *tail*; 4thly, the *want* of *gills*; and

5thly, the *want* of *feet*;—as the *five* different characters whereby the *five* several orders are classed, strikes me as being too *varied*, and too much departing from simplicity and uniformity; which, in my opinion at least, are so essential in every classification, and in which indeed consist the real ability and clearness of the methods of arrangement, so manifest in the Linnean 'Systema Naturæ.'

Although I may thus differ from my friend Prof. Bell in his view of the above classification, yet I must be allowed to call the attention of my readers to his able essay on the *Amphibia*, in which are given instructive and perspicuous descriptions, not only of the anatomical, but also of the physiological structure and organization, of this class of animals.—The essay is illustrated with many good woodcuts, and is contained in Todd's 'Cyclopædia,' Part I, p. 90, &c., published in June, 1835.

The last arrangement which I have met with, is that introduced by Mr. Kirby, in his Bridgewater Treatise, (vol. ii. p. 415), as here shown.

REPTILES.

Sub-class I. SOFT-COATED. *(Reptilia Malacoderma).*

Order 1. AMPHIBIANS. Siren. Proteus. Axolotl, &c.

Order 2. BATRACHIANS. Amphiuma. Triton. Salamander. Toad. Frog. &c.

Next, if one person should be desirous of classifying the *Amphibia*, as the Count de La Cépède, M.M. Duméril, Oppel, and others have done, by making the *tail*, or the *absence* of one, the characters of the *adult* animals, for his *two* divisions or orders; the modern genera would then be distributed in this manner.—

Order I.—UROPHORA. *Tail* present.

Genera.—*Cæcilia. Salamandra. Salamandrina. Molge. Triton. Menopoma. Amphiuma. Siren. Parvibranchus.*[1] *Proteus. Menobranchus. Siredon.*

Order II.—ANURA. *Tail* wanting.

Genera.—*Rana. Ceratophrys. Hyla. Bufo. Rhinella. Otilopha. Dactylethra. Bombinator. Breviceps. Astrodactylus.*

Also, if another person should prefer to characterise these animals by the *want* or *number*, of *feet*, when in their perfect or full-grown state, the annexed classification may be conveniently used.

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[1] As the generic name *Pseudobranchus* is apt to convey an incorrect idea, concerning the use and function of the *small gills*, in the branchial classification herein subsequently given, I have thought it right to substitute that of *Parvibranchus* for it. See Cuvier's note (²) at p. 121, tome ii, of the 'Règne Animal,' edit. 1829.

Order I.—APODA. *Without* feet.
Genus.—*Cæcilia.*

Order II.—DIPODA. With *two* feet.
Genera.—*Siren. Parvibranchus.*

Order III.—TETRAPODA. With *four* feet.

Genera.—*Rana. Ceratophrys. Hyla. Bufo. Rhinella. Otilopha. Dactylethra. Bombinator. Brevieeps. Astrodactylus. Salamandra. Salamandrina. Molge. Triton. Menopoma. Amphiuma. Proteus. Menobranchus. Siredon.*

Again, if a third person should arrange all the *adult Amphibia* according to their external *forms*, or mere shapes, the genera may be thus placed in four groups, or, as I shall here call them, orders, for the sake of concinnity.

Order I.—ANGUIFORMIA. *Snake-like.*
Genera.—*Cæcilia. Amphiuma. Siren. Parvibranchus.*

Order II.—RANIFORMIA. *Frog-like.*

Genera.—*Rana. Ceratophrys. Hyla. Bufo. Rhinella. Otilopha. Dactylethra. Bombinator. Brevieeps. Astrodactylus.*

Order III.—LACERTIFORMIA. *Lizard-like.*

Genera.—*Salamandra. Salamandrina. Molge. Triton. Menopoma. Proteus. Menobranchus.*

Order IV.—PISCIFORMIA. *Fish-like.*
Genus.—*Siredon.*

Having before observed that I selected the *permanency* of the external *gills* for the character of an *Order*, in which to place the *Proteus;* I will now subjoin an arrangement, including both *that* order, which corresponds with the *second* order previously instituted by Latreille,[1] and also his *first* order. To these I have added *two* more orders; one, *Abran-*

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[1] But it is interesting to learn from Prof. Owen's paper mentioned above that the eminent John Hunter first suggested the idea of partly characterising these animals by their *branchiæ* or gills. Mr. Owen says (p. 214),—"the *Siren*, the *Amphiuma*, the Kaltewagoe or *Menopoma* of Harlan, in short, all the "*reptiles douteux*" of Cuvier that Mr. Hunter was acquainted with, he considered as a distinct *Class*, which he denominates "*Pneumobranchia*," in the manuscript which is quoted by Rusconi, in the work entitled 'Amours des Salamandres Aquatiques,' (p. 12, 1821), and which is now published in the 'Physiol. Cat. of the Hunterian Collection,' vol. ii. p. 145, 1834.

chia, denotes that the *gills* (so far at least as is yet known) are always *wanting*: and another, *Imperfectibranchia*, signifies that the *gills* are either by nature *imperfect*, or that we have only at present an *imperfect knowledge* of them. The latter, as will be supposed, I have introduced as a *provisional* order. This arrangement will be found also to combine all the characters given in the last *three* classifications. I have likewise considered it preferable to agree with that systematic writer, and several others of the present day, in making the *Amphibia* constitute an entire *Class* by themselves. Yet I ought to state, that one of the distinctions relied upon for that object by some zoologists,—respecting the heart of these animals having but *one auricle*, and one ventricle, (cor uniloculare *uniauritum*),—and in which Cuvier himself especially coincided; for, even in his last edition (1829) of the 'Règne Animal,' he remarks that the *single* auricle is common to,[1] and therefore characteristic of, the *Batrachian* order,—does *not* in reality exist, as Prof. Owen lately discovered in his very skilful dissections of the hearts of some of the *doubtful* species, and in particular of that of the *Siren lacertina*.[2] It appears then from the accounts mentioned in his paper, which is published in the 'Zoological Transactions,' (vol. i. p. 213, 1835), that the *heart* of the *Amphibia* has *one uniform exterior*, but is in the *interior* separated into *two* distinct *auricles*.[3] That distinguished comparative anatomist observes

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[1] His words are,—" n' ont au cœur qu' *une seule oreillette*, et un seul ventricule."—'Règne Animal,' tome ii. p. 101.

[2] See the beautiful preparations of the *Siren*, numbered 912, 913, 914; and particularly 913, A, which shows the internal structure of the *two* auricles in the heart of that animal,—in the Museum of the Royal College of Surgeons, in London.

[3] Hunter instituted an elegant system of classing those animals which have a *heart* (καρδία) by its *cavities*, (κοιλίαι);—" for in some animals" (as he observes) " it has only one, others two, others three, and the most complete of all four cavities; and this difference of structure forms so many grand divisions of the animal kingdom, which I must be permitted to call by the names of *Monocoilia*, *Dicoilia*, *Tricoilia*, and *Tetracoilia*."—(See Phys. Cat. vol. ii. p. 147). In the third order, *Tricoilia*, he places all the *Amphibia*, Linn., from their having two auricles and one ventricular cavity; but his pneumobranchiate tribe he referred to the second order, *Dicoilia*, from their having only one externally visible auricle, and one ventricle.—The *Radiata* were named *Acardia*. Upon this system Mr. Owen justly remarks,—" like all classifications founded on the variations of a single organ, the *cardiac* arrangement is too artificial for general application."—(Note in *loc. cit.*) The same objection cannot equally apply to the *branchial* classification here proposed, because the *absence* and *presence* of *gills* form distinct and *externally* apparent characteristics in these animals; whereas, on the contrary, the chambers of the heart, being *internal* organs, can only be examined by very careful dissections.

(*loc. cit.* p. 217),—"the presence of *two auricles* in the heart of the *reptiles douleux* now renders applicable to the whole class of reptiles the phrase "cor uniloculare *biaurilum*," and forms an additional argument for retaining as an *order* of that class, the *Amphibia* of Latreille." Nevertheless, for several reasons, which are unnecessary to be here given in detail, but more especially on account of the remarkable *transformations* undergone by so many of these creatures, and of the *branchial apparatus* pertaining to almost all the rest, I do consider myself fully justified in keeping the *Amphibia* in a *class* altogether apart from the *Replilia.* I will therefore limit the class "*Amphibia*" of Linnæus, to the *last* family of the ophidians, and to *all* the batrachians in the *fourth* order of the *third class,*—"Reptiles,"—according to the Cuvierian system. Hence, the present class, *Amphibia,* will occupy an intermediate station between the class *Reptilia* and the class *Pisces;* and in order to show better the connecting link in the great chain of this portion of the animal creation, whereby the several kinds of the former approximate to those of the latter, I place the genus *Cæcilia* the first, on account of its great resemblance to some of the *ophidians,* or serpents, with which indeed many naturalists, besides Cuvier, have classed it.—and I terminate the *amphibians* by the family *Proteidæ,*—which by their permanent and fully-developed gills so closely approach to fishes ;—and among them, the genus *Siredon* I station quite the last, because *Sir. pisciformis,* the *Axolotl,* is in shape and structure most nearly allied to a fish.

Division I.—*VERTEBRATA.*

Class IV.—*AMPHIBIA*

Sub-class I.—*MONOPNEUMENA.* Respiring singly; *either* by lungs only, *or* by gills alone.

Order I.—ABRANCHIA. Gills *wanting.*

Family 1. *Cæciliadæ.* Body lengthened, slender, snake-like. Tail extremely short. Legs none.

Genus.—*Cæcilia.*

Order II.—CADUCIBRANCHIA. Gills *decaying.*

Family 1. *Ranidæ.* Adult body short, roundish, or oval, broad. Tail wanting. Legs four. Tongue long. *Tympanum* open.

Genera —*Rana. Ceratophrys. Hyla. Bufo. Rhinella. Otilopha.*

Might not the *Fishes* also be clearly arranged in one uniform *branchial* classification, by the difference of form, structure, position &c. of their *gills?*

Family 2. *Dactylethridæ.* Adult body short, frog-like. Tail none. Legs four. Tongue distinct. *Tympanum* hid.

Genera.—*Dactylethra.* *Bombinator.* *Breviceps.*

Family 3. *Astrodactylidæ.* Adult body short, flat, frog-like, tailless. Legs four. Tongue wanting. *Tympanum* hid.

Genus.—*Astrodactylus.* *(Pipa).*

Family 4. *Salamandridæ.* Adult body long, lizard-like. Tail long.—Legs four.

Genera.—*Salamandra.* *Salamandrina.* *Molge.* *Triton.*

Sub-class II.—*DIPLOPNEUMENA.* Respiring doubly; *both* by lungs *and* gills.

Order III.—IMPERFECTIBRANCHIA. Gills *imperfect.*

Family 1. *Menopomatidæ.* Body long, lizard-like; or lengthened, snake-like; with a tail. Legs four. Gill-like organs internal.

Genera.—*Menopoma.* *Amphiuma.*

Order IV.—MANENTIBRANCHIA. Gills *permanent.*

Family 1. *Sirenidæ.* Body lengthened, snake-like, having a tail. Legs two in front. Gills tufted, external.

Genera.—*Siren.* *Parvibranchus.*

Family 2. *Proteidæ.* Body long, lizard-like, or fish-like, with a tail. Legs four. Gills ramified, external.

Genera.—*Proteus.* *Menobranchus.* *Siredon.*

It will be here noticed that I have chosen the *modes* of respiration, and the *respiratory organs,* for the principal characters by which to divide the whole class into two leading sections, or *sub-classes.* The *absence,* the *decay,* and the *permanency* of gills, materially influencing the respiratory system, and so affording the most natural properties for the subdivision of the animals into their respective orders, present a classification, at once simple and uniform. And I cannot but consider, that these organs furnish the truest *characters* for more accurately distinguishing the several groups, not only in accordance with the most singular and curious phenomena, which have hitherto been found to arise from their physiological conformation, but also in direct explanation of their common name, '*Amphibia,*' and in farther elucidation of their supposed *amphibiousness.*

Some observations explanatory of the *sub-classes, orders,* and *families* adopted by me, may not now be deemed superfluous.

The *first* sub-class comprises the *monopneumenous* amphibians, or those animals in which the function of respiration is effected by means of a *single* breathing-apparatus ; that is to say, *either* altogether by *lungs* alone, *or* else *at first* by gills and *then* by lungs.

This *sub-class* includes the *first* and *second* orders. The *first* order gives the *abranchians*, viz., such animals as are never found to be furnished with gills at any time of their existence ; wherefore they always breathe atmospheric air, and the consequent circulation of the blood is, of course, merely pulmonary. There is only one *family* in this order, —the *Cæciliadæ ;* which naturally constitute a link intermediate between, and allied to, both the ophidians and the true amphibians : to the former they are similar in their external forms, in having neither legs nor gills, and from their second lung[1] being much smaller than the first ; to the latter they approach in the smallness and shortness of their ribs, and in the formation of their hyoid bones, from the appearance of which one might be induced to suspect that some branchial apparatus once existed, and that a metamorphosis had actually taken place.

The *second* order embraces *all* those animals which (as yet are known to) undergo any metamorphosis : these are the frogs, the frog-like amphibians, and the family of salamanders. In their early forms, *larvæ* or tadpole stages, they breathe by *gills* in the water, just as fishes do ; and after their transformations, or in their perfect state, they respire simply by the aid of *lungs* in the atmosphere. Hence, the term '*Caducibranchia*' sufficiently points out as well the phenomena exhibited by the changes in the forms of this natural group, as their most singular qualities,—of *first* respiring in water by *gills*, which, when they have performed their service to the immature creatures, become obliterated, or decay, together with their cartilaginous arcs and deciduous lids or *opercula ;* —and of *afterwards* respiring in air by proper and fully-developed *lungs.*[2] And the circulation of the blood in the one case would be *branchial,*[3] but in the other only pulmonary.

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[1] Cuvier observes, "leur deuxième poumon est aussi petit que dans les autres serpens."—'Règne Animal,' tome ii. p. 99.

[2] Les batraciens "ont tous deux poumons égaux, auxquels se joignent, dans le premier âge, des branchies qui ont quelque rapport avec celles des poissons, et que portent aux deux côtés du col des arceaux cartilagineux, qui tiennent à l' os hyoïde. La plupart perdent ces branchies et l' appareil qui les supporte, en arrivant à l'état parfait."—Cuvier ; 'Règne An. tome ii. p. 101.

[3] The circulation through the external branchial tufts of the young tadpoles of the *common frog*, when only three or four days old, affords a very interesting object for the microscope. The globules of blood may be seen passing, in a distinct current, down one side of the transparent finger-like

In this order I have divided the animals into *four* families, characterized by the shape of their body when adult, their tailless form, the presence of a long tail, &c.

I must here observe, that although the *adult* caducibranchians may be well ascertained and correctly specified, we know little of the exact varieties of form assumed and changed by the *larvæ* of each species; to describe indeed the tadpoles of one or two species of any of the genera of that order, otherwise than the *supposed general* appearance of those of all the species, is clearly incorrect; for careful investigations have only been made on the tadpoles of the common frog, the edible frog, the toad, the aquatic salamander,[1] and probably a very few other species, but of the greater number of those of the more rare and foreign kinds, we are at present quite ignorant. So likewise we know nothing of the very first appearance of the immature animals,—I mean especially when first produced from the *ova*,—belonging to the latter, or *Amphibia Diplopneumena*, which are supposed never to transform; concerning them, I expect, Zoology will some day receive many curious facts.

The *second* sub-class, or *diplopneumenous* kinds of amphibians, are those which respire by the aid of a *double* breathing apparatus, namely, by lungs *and* by gills, or gill-like organs, both of which the animals *simultaneously* retain during the *whole* period of their life. So that consequently the circula-

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processes or lobes of the external *branchiæ*, turning round the tips or extremities, and ascending up the opposite side. The blood continues to circulate with great velocity, and in a regular and continued stream. This phenomenon struck me as one of the most beautiful I ever beheld.

[1] Those who wish to pay attention to this subject, and "mutatas dicere formas" of the different *larvæ*, I refer to the three following beautifully-illustrated monographs by Dr. Rusconi, as examples worthy of their imitation.—'Descrizione Anatomica degli organi della circolazione delle Larvæ delle Salamandre Acquatiche:' con tavola: 1817. 'Amoures des Salamandres Aquatiques, et developpement du tétard de ces Salamandres depuis l' œuf jusqu' à l'animal parfait.' 1821. 'Developpement de la Grenouille commune, depuis le moment de sa naissance jusqu' à son état parfait.'—1826. And see Humboldt and Bonpland's Voyage, vol. i. part 2 plate 13, for Cuvier's illustrations of the tadpoles of *Bufo fuscus* and *Salamandra aquatica*. Sir E. Home also published in the 'Phil. Trans.' for 1825, p. 81, a paper "On the changes the *ovum* of the Frog undergoes during the formation of the Tadpole," illustrated by accurate and beautiful plates from the pencil of Bauer; but he has neglected to give a representation of the singular mode in which the *external branchiæ* are often seen to disappear, about the sixth or seventh day from the birth. On one side the little creatures (in some specimens) exhibit at that age no appearance of external tufts; and on the other side, only the extremities of these tufts are visible, being nearly *drawn within* the cervical aperture.

tion may be named *branchipulmonary*, that is, *both* branchial *and* pulmonary; and therefore either the one or the other takes place as the respiration of the animals is aquatic or atmospheric. In this sub-class are comprised two orders.

The *third* order,—*Imperfectibranchia*,—is provisionally instituted in consequence of our present imperfect knowledge of the two American genera, *Menopoma* and *Amphiuma*, which alone constitute it.

These extraordinary creatures appear to have only *imperfect* gills, or rather *gill-like* organs, for they are not known to possess the *external* branchial tufts, which permanently belong to, and form the chief character of, the following order, though they are always furnished with the rest of the gill-like apparatus, viz., the branchial openings on the sides of the neck, the membranous lids or *opercula*, and cartilaginous arc formed from the hyoid bone. From a careful examination of these organs in the beautiful specimens of the anterior portions of the *Amphiuma means*[1] and the *Menopoma Alleghaniense*,[2] prepared by the celebrated John Hunter; and after attentively comparing them with the very similar parts in the *Proteus*[3] and *Siren*,[4] I think I have sufficient grounds, during our present confined knowledge at least, for maintaining that they, in all probability, do some service analogous to the true gills of the latter, and that they assist in, if they do not altogether perform, the function of respiration in the water. I was unable to perceive any particular difference in the structure of the branchial, pulmonary (except as to the origin of the pulmonary arteries), and circulatory organs, between the *Amphiuma* and the *Menopoma*, as exhibited in these specimens; wherefore the description of those organs in the one, will suffice for both the animals. Mr. Hunter, in his own account of the dissected specimen of the *Amphiuma means* just referred to, and which is lately published in the 'Physiological Catalogue of the Hunterian Collection' (vol. ii. *note*, p. 151), calling the imperfect branchial organs *gills*, thus describes them.—" The gills are composed of three cartilages, which are placed in the same manner as gills in fish; but these cartilages have neither the pectinated part nor the mushroom partition, which those of fish have; their ends are articulated together, and the whole is joined to the extremity of the same bone as that of the tongue. From the *fauces* there is an opening outwards, between the two inferior cartilages of the gills, for the water to pass. In this opening, which is oblong, is placed a structure composed of two valves, which will obstruct the water passing in from without. The two cartilages which are above the opening, between which the two arteries pass, are lined on the inside by the membrane of the *fauces*, which is not very thin." Next, the *aorta*, or great artery, arising from the ventricle of the heart, swells at its upper part into a bulb-like bag (*bulbus arteriosus*), from the extremity of which there proceed eight smaller arteries, four diverging to the right side and four to the left; one of the lower arteries, on each side, passes downwards and enters upon the top of each lung, along which it ramifies, and forms the *pulmonary* artery.[1] The other arteries branching off from the arterial bulb on each side, proceed outwards to the *gills*, and becoming the *branchial* arteries, " there wind round and between the cartilages of those parts," both on the left and on the right side; thence, coming round towards the back, they unite into a single trunk on either side, which, running to the backbone, afterwards constitute (with other branches) the *aorta descendens*. This organization then proves the circulation of the blood to be *twofold*, and in fact *branchipulmonary*, or *pneumobranchial*, as it has been well named by Hunter, for there are two distinct arteries (*pulmonary*) leading to the two lungs, and as many separate *branchial* arteries wind around the gill-like organs, as there are such organs or gills in number.[2] This circulation is nearly identical with that of the animals in the next order of *Amphibia*, which have complete and persistent *branchiæ;* the only difference is, that in the latter the branchial arteries send off *branches*, which enter and ramify through the external gill-tufts attached to the ends of the hyoidean arcs, in order that the blood may be more subjected to the influence of the water. Now, I cannot imagine that the *whole* function of the aquatic respiration in the manentibranchious amphibians is performed by the *external gills* alone, but I conceive it to be not improbable that a portion of it is aided, and in part effected, by the *internal branchial arcs* themselves. The American authors[1] assert that the *Amphiuma* and *Menopoma* have never been seen with any external gills, but that the rest of the branchial apparatus remains unchanged throughout life; unless then this apparatus be superfluous or useless, (which I cannot suppose at all likely), I think it more than probable that it performs the part of real gills to those aquatic animals; and that the blood, in circulating through the branchial arteries, which wind round and between those cartilages, becomes sufficiently aerated by being submitted to the influence of the water within the cervical apertures, and thus obtains the same effect or benefit, as if the respiration were carried on in the water by means of them and external tufts conjointly, as in the manentibranchians, or by the similar cartilages with their pectinated and membranous appendages, as in the fishes. If so, these two genera are correctly stationed in my *diplopneumenous* sub-class; and it is gratifying to learn that Mr. Hunter held the like opinion, for he has included them, with the *Siren*,[2] in his class which he termed *Pneumobranchia.* That philosophical zootomist, in his 'General Observations[3] on the *Pneumobranchiata*,' has admirably stated his view of their respiration in these two passages.—"This tribe of animals is widely different from all hitherto known. They are compounded of two grand divisions of the animal kingdom, yet not so as for all their parts to partake equally of both; for some parts incline more to the one of these divisions, other parts to the other, while a few are pretty distinctly made up of both, *so as to be truly double*, just as the parts of generation are in perfect hermaphrodites, and *these parts are the organs of respiration*, to which the circulation must of course correspond. They hold with respect to respiration, a middle rank between fish, which breathe water, and those immediately above them, which breathe air, viz., those called *Amphibia* (Linn.), and they are placed in this respect between the two, filling up the scale."........"An animal to be truly amphibious, must have its *respiratory apparatus compounded* of the *pulmonary and branchial* organs, which is *the case with this tribe*, for these only can be said, when in the air, to be truly terrestrial, and when in the water truly aquatic."

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[1] Numbered 915 in the Museum of the Royal College of Surgeons in London; described in the 'Phys. Cat.' vol. ii. p. 43; and figured in Rusconi's 'Amours des Salamandres,' pl. 5, fig. 7, where it is named by mistake "*Siren lacertina*." See Hunter's own description of it in Cat. vol. ii. p. 150, *note*.

[2] Numbered 916 and 917 in the same Museum; described in Cat. vol. ii. p. 45; also therein figured in plates 23 and 24. For Hunter's account from his MS., refer to the same Cat. pp. 149—154.

[3] Vide 'Monografia del Proteo,' da Configliachi e Rusconi; tab. 4, fig. 8: 1819.

[4] See preparation No. 914 in the Museum of the Royal College of Surgeons, and the plate illustrative of Prof. Owen's paper in vol. i. of the Zoological Transactions. Also plate 11, part 2, vol. i. Voyage de Humboldt et Bonpland.

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[1] But the pulmonary artery in the *Menopoma* springs from the end of one of the branchial arteries.

[2] Cuvier says,—" tant que les branchies subsistent, l'aorte, en sortant du cœur, se partage en autant de rameaux, de chaque côté, qu'il y a de branchies." 'Règne Animal,' tome ii. p. 101.

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[1] See Dr. Garden's letter to Linnæus in Smith's 'Correspondence,' vol. i. p. 599. Also Dr. Harlan's paper in the Journal of the Acad. Nat. Sci. of Philadelphia; vol. iii. p. 54. *cum tab.* 1823: and in Annals of the Lyceum of Nat. Hist. of New York, pp. 223, 270, vol. i. 1824.

[2] With the respiratory organs of the *Siren lacertina* he was long acquainted, for that animal became one of his first subjects of comparative anatomy. See his paper in the Phil. Trans. for the year 1766, p. 308.

[3] Now published in the Physiol. Cat. vol. ii. pp. 145 146.

Having before shown that the circulating organs are, in these two genera, *both* strictly pulmonary *and* branchial; and of these, the latter perhaps most prevail, for on either side of the *aorta*, *three* branchial arteries proceed to the gill-like parts, whilst only *one* artery descends upon each lung, and this organization is said to continue unaltered during the entire life of the animals; wherefore, it is almost naturally certain, that the *respiration* itself, like the corresponding circulation, is also *two-fold*,—*both* branchial or aquatic, *and* pulmonary or atmospheric. Again, by comparing these organs with those of the caducibranchians, or such animals as undergo a metamorphosis, for example, with those of the *water salamander*, we see that the branchial arteries proceed in the same course[1] in the young or tadpole, when its respiration is entirely aquatic; but when the lungs are fully developed, the pulmonary arteries are prepared for action, and when the gill apparatus is decayed, all the branchial arteries (except two) with their branches become obliterated, and the two remaining (formerly branchial) arteries unite into one at the back, and send off a branch directly to the lung;[2] and since the gills, the arcs, the apertures, and opercles, in the adult become quite evanescent, the two arteries (branchial) can no longer be of any service in aquatic respiration, for they are not exposed to, or in anywise influenced by, the water. The entire respiration is ever afterwards effected by the lungs alone in the atmosphere. But it has been already explained that the branchial arteries continue, in the *Amphiuma* and *Menopoma*, always to wind round and between the permanent arcs or gill-like organs, and to expose the blood contained within them to the water, either passing through the cervical openings, or therein retained by the closing of the persistent lids; thus do they differ in a most essential way from the final condition of the similar parts in the mature *salamander*,[3] and in other amphibians which have changed their forms; consequently, from these comparisons I feel tolerably confident, that some use of those permanent organs, in the animals now under notice, may be derived by them in the function of respiration whilst in water; although satisfactory proofs of this supposition can only be established by future experiments, to be made for the express purpose of investigating that important question. The *third* order comprehends a single family, which I have named *Menopomatidæ*, by taking the appropriate title of the genus *Menopoma*[1] for its type.

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[1] This may be well seen on referring to the plates in Rusconi's 'Amours des Salamandres,' and to plate 13, part 2, vol. i. Voyage de Humboldt.

[2] Cuvier correctly writes,—" dans les espèces qui perdent leurs branchies, les rameaux qui s'y rendent s'oblitèrent, excepté deux, qui se réunissent en une artère dorsale, et qui donnent chacun une petite branche au poumon—.C'est une circulation de poisson métamorphosée en une circulation de reptile."—Règne Animal, tome ii. p. 102.

[3] Compare fig. 6, representing this adult animal anatomically displayed,

The retention of external branchial tufts or ramified gills, with permanent hyoidean arcs, and mostly with lids or opercles, is distinctly intended by the word that denotes this last order,—*Manentibranchia.*

The two families I have distinguished principally by the *form* of the body and the *number* of the legs. The genera will exhibit (among other marks) the variations in the *number* of toes.

The comparative naturalist will here with pleasure consider, how the steps in the gradation of the different respiratory systems, among the higher classes of the animal kingdom, are nicely and beautifully varied; how inimitably and gradually they lead from the most complete to the inferior development; and how the transition from a perfect pulmonary respiration to a perfect branchial one, is gently, and not instantaneously, effected. For in the *Mammalia*, birds, and reptiles, there are lungs more or less perfect; in the *Amphibia* there exist, *first*, well-formed lungs without gills;—*secondly*, at first perfect gills and no lungs, afterwards lungs without gills;—*thirdly*, imperfect gills co-existing with lungs; —*fourthly*, perfect gills with less-developed lungs;—and *lastly*, in the fishes, most complete gills, but lungs entirely wanting.

If, however, it should be hereafter found, that the gill-like organs in the *Menopomatidæ* are in reality *gills*, or merely a

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in pl. 5 of Rusconi's 'Amours,' with the *Amphiuma means*, fig. 7 of the same plate: also examine the preparation of the Surinam toad, No. 917 A, in the Museum of the Royal College of Surgeons.

[1] Dr. Harlan bestowed that appellation on this genus, because the *opercula* are *persistent:* it is derived from μένω, *maneo*, and πῶμα, *operculum*.

With regard to the name of the second genus, Dr. Wagler observes,—"der sippename *Amphiuma* wird wohl verändert werden müssen. Was soll *Amphiuma* heissen?" The generic name well deserves to be changed.—What does *Amphiuma* signify? I conclude that it is derived from ἀμφι, *circà*, and ὕμα for ὕσμα, *pluvia*;—circà pluviam, *i. e.* aquam habitans,—from its frequenting pools left by the rain and other waters.

peculiar *modification* of gills, by which the air from the water is imparted to the blood in the branchial arteries, I would then erase the provisional order *Imperfectibranchia*, and thus re-arrange the last sub-class:—

Sub-class II.—*DIPLOPNEUMENA.*

Order III.—MANENTIBRANCHIA.

Tribe 1. *Internibranchia.* Gills plain, *internal.*

Family. *Menopomatidæ.*

Tribe 2. *Externibranchia.* Gills tufted or ramified, *external.*
Families. *Sirenidæ. Proteidæ.*

But, on the contrary, should future experiments prove that the branchial apparatus in the *Menopomatidæ* is decidedly *imperfect*, and that it has *no* share whatever in aquatic respiration, then it will become necessary to modify my classification after this manner:—

Class IV.—*AMPHIBIA.*

Sub-class I.—*MONOPNEUMENA.*

Order I.—ABRANCHIA. Branchial apparatus *none.*
Family. *Cæciliadæ.*

Order II.—CADUCIBRANCHIA. Branchial apparatus *decaying.*
Families. *Ranidæ. Dactylethridæ. Astrodactylidæ. Salamandridæ.*

Order III.—IMPERFECTIBRANCHIA. Branchial apparatus *imperfect.*

Family. *Menopomatidæ.*

Sub-class II.—*DIPLOPNEUMENA.*

Order IV.—MANENTIBRANCHIA. Branchial apparatus *remaining.*
Families. *Sirenidæ. Proteidæ.*

And lastly, if the *Menopomatidæ* be hereafter ascertained to undergo a metamorphosis; and if the very young animals really possess the *external branchiæ*, but which are *very early* deciduous; which Cuvier thought likely, for he says,—"probablement qu'ils les perdent d' aussi bonne heure que notre salamandre terrestre;"[1]—and the branchial arcs, lids, and apertures remain permanent throughout life; I will, in such case, propose the following arrangement:—

Class IV.—*AMPHIBIA.*

Sub-class I.—*MONOPNEUMENA.*

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[1] Vide 'Règne Animal,' tome ii. p. 117, edit. 2.

Order I.—ABRANCHIA. Gills *wanting.*
Family. *Cæciliadæ.*

Order II.—CADUCIBRANCHIA. Gills *deciduous.*
Tribe 1. *Arcucadentia.* Branchial arcs *deciduous.*
Families. *Ranidæ. Dactylethridæ, Astrodactylidæ. Salamandridæ.*
Tribe 2. *Arcumanentia.* Branchial arcs *persistent.*
Family. *Menopomatidæ.*

Sub-class II.—*DIPLOPNEUMENA.*

Order III.—MANENTIBRANCHIA. Gills *permanent.*
Families. *Sirenidæ. Proteidæ.*

It was my desire to have given fuller definitions of the several sub-classes, orders, tribes, and families, and to have added characters of all the genera, which I have here thought right to adopt; but professional occupations at present entirely prevent the completion of that task.

With respect however to the word *Amphibia*, used to denominate this class of animals, its literal meaning signifies the being able to *live both* on land *and* in water,—that is to say,—the having at the same time *two* natures or faculties of *life;* namely, the faculty of life in the *air*, and the faculty of life in the *water*. Now, the great vital principle, or original spring of *life*, is respiration; hence, whatever animal has the faculty of respiring freely *both* in the atmosphere *and* in water, can alone be strictly called *Amphibious*. Moreover, lungs are—in the *higher* classes of animals—the only apparatus that can perform the function of the former; and gills are the peculiar apparatus adapted to that of the latter. It is therefore evident, that all creatures not furnished with *both* lungs *and* gills, are naturally disabled from ever enjoying *real* amphibiousness, or the *twofold* faculty of life; and so, none of the animals of this class, which belong to the *Monopneumena*, can receive the epithet of *amphibious* in its full and literal sense; and of those belonging to the *Diplopneumena*, the *Amphiuma means*, the *Siren lacertina*, and the *Proteus anguinus*, as far as we have yet learned, are alone entitled to it. It is nevertheless more than very probable, that the greater number (if not all) of the *second* sub-class, will hereafter be proved to be *strictly* amphibious.

Amongst other interpretations of this word, and in its *restricted* but more common meaning, nearly the whole of the monopneumenous animals may be called *amphibious*,[1] for the greater part of them, although in their *adult* state terrestrial animals, are in the habit of resorting to lakes, ponds, and other fluviatile places, and are capable of remaining under the water[1] for a considerable length of time, without rising to the surface in order to inhale atmospheric air In this sense, then, it is, that we must confine the signification of *amphibious*, as almost universally made use of; and certainly it is to be so translated in the following lines of the very ancient poet;—

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[1] In this sense are to be understood the animals which Cuvier names "*les Amphibies*," consisting of the genera *Phoca* and *Trichechus*. In his System they form the third and last tribe of the *Carnivora*.

> *Α'μφίβιον γὰρ ἔδωκε νομὴν Βατράχοισι Κρονίων,*
> *Σκιρτῆσαι κατα γῆν, καὶ ἐφ' ὗδασι σῶμα καλύψαι.*
> Homeri Batrach. v. 59.

> (For we, *amphibious*), " by gift from Jove,"
> (Do) " leap as well as swim, can range the land
> " For food, or diving, seek it in the deep."
> Cowper: Trans. v. 79.

Now, whether this power of remaining long submerged under water, without performing the function of respiration, arises from the cold blood in these animals, when first sufficiently aerated, being able to continue its slow circulation for a considerable time together; or, from the lungs having the capacity of retaining such a quantity of air, as to permit the circulation to go on uninterruptedly, for a long period; or, from the circulation being in some degree carried on independently of the lungs; because, in these amphibians, the blood is only in part passed through the lungs and so aerated, while the other part circulates again from the heart, through the rest of the body, independent of transmission through the pulmonary organs; or from the pulmonary vessels being so small as to allow the respiration to be suspended, without stopping the circulation of the blood; or from whatsoever organic cause[2] it may be considered to be effected, I will leave anatomists to decide. But I must remark, that notwithstanding important zootomical examinations have been made upon the *Siren lacertina*, the *Proteus anguinus*, the *Siredon pisciformis*, the *Menopoma Alleghaniense*, and the *Amphiuma means;*[1] still, experiments directly in reference to the supposed faculty possessed by these, and other species, of respiring with ease both in the water and in the atmosphere, ought to be carefully instituted, on several living and healthy specimens, in various stages of their growth and age, in their natural countries or abodes; so that it may be ascertained with certainty how far each of them is to be esteemed *amphibious*, how necessary, or useful, the gills or branchial apparatus, and the lungs individually, may prove to those kinds that are furnished with both these organs; and how their respiration may be affected by the variations of temperature, and other atmospheric causes. At the same time, due attention being paid to any chemical changes that may take place in the water in which they may be kept. Of the discoveries likely to result from such investigations, we are now totally ignorant; but I feel perfectly assured that such observations would not fail to afford to science many new and interesting facts, in regard to the physiological relations of these, as yet, little known, and most extraordinary animals.

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[1] Many of the monopneumenous *adult* amphibians are admirably adapted to an *aquatic* life, in having some of their organs protected against injury from the water, and in having others so formed as to be of material assistance to them, when diving in that element. Of the former are, the nostrils, (through which alone many sorts breathe), which are often furnished with small valves, to prevent both the entrance of water, and the escape of the air inhaled for respiration; the ears are usually covered by a membrane, and the eyes are defended by two, or even three, eyelids: of the latter, are, the crystalline lenses in the eyes of some kinds, which assume a more spherical shape, approaching to those in fishes, the toes of the hind feet are frequently webbed, and the tails, sometimes being compressed, greatly aid in swimming.

[2] I have not made any allusion to a *third* mode of *respiration*, with which some of these animals are endowed; *namely*, that of breathing water, or atmospheric air, by means of their *skin*; because, how far this *cutaneous* respiration is really possessed by, or of actual service to, the different groups of the *Amphibia*, is as yet unknown.

Temple, London;
February 5th, 1838.

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[1] For the details of the organization of the first three animals, see Cuviér's 'Recherches Anatomiques sur les Reptiles Douteux,' (1807); published at p. 93, in part 2, vol. i. of 'Voyage de Humboldt et Bonpland; also MM. Configliachi et Rusconi's Monograph for the *Proteus;* and Professor Owen's and Mr. Hunter's papers already quoted, for the *Siren*, as well as the two last animals.